

CLAIMS:

1. A plasma processing system comprising:
 - a chamber containing a plasma processing region;
 - a chuck, configured to support a substrate within the chamber in the processing region;
 - a plasma generator in communication with the chamber, the plasma generator being configured to generate a plasma during a plasma process in the plasma processing region;
 - a magnetic field generator configured to produce a magnetic field in the chamber;
 - a sheet optic element in communication with the chamber, the sheet optic element being configured to produce a light sheet capable of illuminating particles in the chamber;
 - an imaging device configured to acquire image data corresponding to the particles illuminated by the light sheet,

wherein the magnetic field generator, the sheet optic element and the imaging device are positioned relative to one another to access the plasma; and

an image processor in communication with the imaging device, the image processor being configured to process the image data so as to obtain a concentration of particles in the light sheet.
2. The plasma processing system of claim 1, wherein the sheet optic element includes at least one of a cylindrical lens, a mirror and a prism.
3. The plasma processing system of claim 1, wherein the sheet optic element includes a cylindrical lens and a spherical lens.

4. The plasma processing system of claim 1, further comprising a scanning mirror which cooperates with the sheet optic element to produce the light sheet.

5. The plasma processing system of claim 1, further comprising a light source operatively associated with the sheet optic element.

6. The plasma processing system of claim 1, wherein the imaging device is a camera.

7. The plasma processing system of claim 1, wherein the magnetic field generator is positioned external the chamber and has a substantially annular configuration.

8. The plasma processing system of claim 1, wherein the sheet optic element and the imaging device are positioned above the magnetic field generator.

9. The plasma processing system of claim 8, wherein the sheet optic element is movably mounted to at least one wall of the chamber.

10. The plasma processing system of claim 1, further comprising at least one additional sheet optic element configured to produce at least one additional light sheets capable of illuminating at least one additional plane in the chamber.

11. The plasma processing system of claim 10, wherein the imaging device is configured to acquire image data corresponding to particles in the chamber

while the particles are illuminated by the light sheet and the at least one additional light sheet.

12. The plasma processing system of claim 11, wherein the light sheet illuminates the particles with a first light color and the at least one additional light sheet illuminates the particles with a second light color, different from the first light color.

13. The plasma processing system of claim 12, wherein the image processor is configured to distinguish the illuminated particles by the color thereof so that particles illuminated with the first light color can be distinguished from particles illuminated with the second light color.

14. The plasma processing system of claim 10, wherein the sheet optic element and the additional sheet optic element each are at least one of a cylindrical lens, a mirror and a prism.

15. The plasma processing system of claim 10, further comprising a light source operatively associated with the sheet optic element and at least one additional light source operatively associated with the at least one additional sheet optic element.

16. The plasma processing system of claim 15, wherein the light source is a laser having a first wavelength and the additional light source is a laser having a second wavelength.

17. The plasma processing system of claim 15, wherein the light source includes a first color filter and the additional light source includes a second color filter.

18. The plasma processing system of claim 10, wherein at least one of the sheet optic element, the imaging device and the additional sheet optic is fixedly mounted relative to the chamber.

19. The plasma processing system of claim 1, wherein the sheet optic element is movable relative to the chamber such that the sheet optic element is configured to produce the light sheet at multiple planes in the chamber.

20. The plasma processing system of claim 19, wherein the sheet optic element is rotatable about an optical axis thereof to rotate the light sheet through multiple planes in the chamber.

21. The plasma processing system of claim 19, further comprising a drive mechanism coupled to the sheet optic element and configured to move the sheet optic element in a substantially arcuate direction.

22. The plasma processing system of claim 21, wherein the imaging device is synchronized with the drive mechanism such that the imaging device is configured to acquire three-dimensional data corresponding to the particles in the chamber while the particles are illuminated by the light sheet.

23. The plasma processing system of claim 22, wherein the image processor is configured to obtain data relating to the position of the sheet optic element relative to the chamber.

24. The plasma processing system of claim 23, wherein the obtained data includes angular data corresponding to an imaging angle of the sheet optic element relative to the chamber.

25. The plasma processing system of claim 24, wherein the image processor is configured to de-project an image based on at least the angular data.

26. The plasma processing system of claim 21, wherein the arcuate movement of the sheet optic element relative to the chamber rotates the light sheet through multiple planes in the chamber.

27. The plasma processing system of claim 19, further comprising a drive mechanism coupled to the sheet optic element and configured to move the sheet optic element about an optical axis thereof.

28. The plasma processing system of claim 18, wherein the drive mechanism rotates the light sheet through multiple planes in the chamber as the drive mechanism moves the sheet optic element.

29. The plasma processing system of claim 1, wherein the magnetic field generator has a passageway formed therein.

30. The plasma processing system of claim 29, further comprising a light source positioned external to the chamber and configured to emit light through the passageway.

31. The plasma processing system of claim 30, further comprising a shield between the light source and the plasma generator, the shield being configured to reduce light scattered outside the passageway.

32. The plasma processing system of claim 30, wherein the sheet optic element is coupled to the wall of the chamber adjacent to the passageway and is operatively associated with the light source.

33. The plasma processing system of claim 10, further comprising a light source configured to emit light through an optical window positioned between the light source and the light sheet and the at least one additional light sheet.

34. The plasma processing system of claim 33, further comprising at least one beam splitter for each additional sheet optic element, the at least one beam splitter being configured to split the light emitted from the light source after passing through the window into multiple light beams, each of the multiple light beams being provided to separate one of the additional sheet optic elements.

35. The plasma processing system of claim 33, wherein the light source includes at least one multi-line laser.

36. The plasma processing system of claim 33, wherein the light source includes a plurality of lasers, at least two of the lasers having different wavelengths.

37. The plasma processing system of claim 10, further comprising a shutter for the sheet optic element and each additional sheet optic element.

38. The plasma processing system of claim 37, wherein at least one shutter is open to allow light to pass therethrough so that the imaging device can acquire image data on each light sheet, thereby allowing particle concentration distributions to be measured in multiple planes.

39. The plasma processing system of claim 10, wherein the sheet optic lens system further includes at least one filter, the at least one filter being configured to separate the light emitted from the light source into multiple colored light beams, each of the multiple colored light beams being provided to each additional sheet optic element.

40. The plasma processing system of claim 39, wherein each filter separates the light into a respective colored light beam so that different colored light beams are provided to the sheet optic element and each additional sheet optic element.

41. A method of measuring particle concentration in a plasma processing system having a chamber containing a plasma processing region in which a plasma can be generated during a plasma process to process a substrate and a magnetic field generator configured to produce a magnetic field in the chamber, the method comprising:

positioning the magnetic field generator, a sheet optic element and an imaging device relative to one another to access the plasma;

producing a light sheet to illuminate particles in the chamber with the sheet optic element;

acquiring image data corresponding to the illuminated particles with the imaging device; and

obtaining a concentration of particles in the light sheet.

42. The method of claim 41, wherein the magnetic field improves plasma uniformity.

43. The method of claim 41, wherein the light sheet is configured to illuminate particles along at least one vertical or horizontal plane in the chamber.

44. The method of claim 41, wherein the light sheet is configured to illuminate particles in the chamber with one color of light.

45. The method of claim 41, further comprising producing at least one additional light sheet to illuminate particles in the chamber with at least one additional sheet optic element.

46. The method of claim 45, wherein the at least one additional light sheet is configured illuminate particles in the chamber with a different color of light than the light sheet.

47. The method of claim 41, wherein the light sheet is configured to illuminate particles in the chamber through the magnetic field generator.

48. The method of claim 41, wherein the light sheet and the at least one additional light sheet are configured to illuminate particles in the chamber with different colors of light.

49. The method of claim 45, further comprising rotating at least one of the light sheet and the at least one additional light sheet through multiple planes in the chamber.

50. The method of claim 49, wherein the rotating comprises rotating at least one of the light sheet and the at least one additional light sheet about an optical axis thereof through multiple planes in the chamber.

51. The method of claim 49, wherein the rotating comprises circumferentially sweeping at least one of the light sheet and the at least one additional light sheet around the chamber through multiple planes in the chamber.

52. The method of claim 41, wherein the producing includes producing at least one of the light sheet and the at least one additional light sheet parallel to the substrate.

53. The method of claim 49, wherein the light sheet and the at least one additional light sheet are configured to illuminate particles in the chamber with different colors of light.

54. A method of minimizing a particle concentration in a plasma processing chamber of a plasma processing system comprising:

positioning a substrate or wafer in a plasma processing chamber to be processed with a plasma;

performing a plasma process on the substrate or wafer;

obtaining a concentration of particles in the chamber; and

modifying the plasma process to reduce particles to a predetermined level within in the chamber.

55. The method of claim 54, wherein the obtaining comprises:
positioning a magnetic field generator, a sheet optic element and an imaging device relative to one another to access the plasma;
producing a light sheet to illuminate particles in the chamber with the sheet optic element;
acquiring image data corresponding to the illuminated particles with the imaging device; and
obtaining a concentration of particles in the light sheet.

56. The method of claim 54, wherein the modifying includes removing particles from the chamber with a plasma pump.

57. The method of claim 54, further comprising repeating the positioning, the performing, the obtaining and the modifying at least one time.

58. The method of claim 54, further comprising processing the substrate or the wafer.